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ABSTRACT

The author begins this address to the Association for the Education of Teachers of Science by consideration of the social context of science education. After discussing the effects of the idea of assimilation of individuals and groups into the American mainstream and of the "youth crisis," he focuses on issues of science curricula. Arguing that the students' cognitive, physical, and social development should be more important than I.Q. in determining appropriate science curriculum, the author observes that multiple science curricula are needed. The tendency of curriculum developers and users to consider science as "the" way of knowing should be replaced with an approach stressing the meaningful use of science as a way of knowing. In conclusion, the author addresses goals of science education and their relation to the politics of science education. (SD)

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CRITICAL ISSUES IN SCIENCE EDUCATION
by
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The issues I will discuss are part of a fabric, the fabric in which children and youth become members of a civilization. Understanding this context in which our speciality, science education, is conducted is of more than passing importance to achieving our goals. The past decade has demonstrated yet again, as did the decade of the 1930's demonstrate to the educational community, that the social-cultural milieu in which we function is a critical factor in what we can accomplish, and in many respects, how we may or may not go about accomplishing it. The critical issues that need deliberation and resolution by those of us in the science education community are interwoven with the societal fabric in ways that we cannot ignore. I will begin, therefore, with a brief sketch of the societal issues as a backdrop for a more detailed review of the issues.

Beyond the obvious science-based, technological character of contemporary America, and the concern or lack of concern with environmental problems is the challenge to the notion of America, the melting pot. Greenbaum (1974), in a very provocative essay, discusses the rise of pluralism as a result of the failure of the Protestant Anglo-American ideal of assimilation.

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In the past, the socialization function of schooling was impelled by two reasons: shame and hope. "The immigrants were best instructed in how to repulse themselves; millions of people were taught to be ashamed of their own faces, their family names, their parents and grandparents, and their class patterns, histories, and life outlooks. This shame had incredible power to make us learn, especially when coupled with hope, the other main energy source for the melting pot--hope about becoming modern, about being secure, about escaping the wars and depressions of the old country, and about being equal with the old Americans."

The decline of the Anglo-American ideal that gave direction and force to the nations' assimilation process has resulted in such skepticism that shame is being replaced by self-respect and a singular definition of hope is being replaced by more pluralistic forms.

Fights in the halls of congress over MACOS and the attempts to control curricula through removing alternatives to commercially produced materials is evidence that the battle will be fought in many places.

The second societal issue that is critical to us is "youth in crisis." The depth of the crisis is most evident to me in the very meager responses afforded to three major studies of youth produced in the last few years (President's Science Advisory Committee, 1973; Task Force '74, 1975; and the National Society for the Study of Education, 1975). The reports found

a powerful erosion in the processes by which youth become adults in American society. Young people are not starving from lack of food as they did in the 1930's. But they are starving in another resource--lack of maturity-promoting experiences. Think of your work with children or youth this past school year. How many maturity-promoting experiences did you offer them? Here are a few examples: "experience with persons different from oneself, not only in social class and subculture, but also in age; the experience of having others dependent on one's actions; and interdependent activities directed toward collection goals." (Havighurst, 1974)

No short paper can address all of the critical issues in science education. I have chosen to focus this paper on what I regard as the issues of central importance: curricula. I use the plural form purposefully; for we have, for too long, tried to determine what the science curriculum should be.

The first curriculum question, I believe, is for whom is the curriculum intended. Who is to benefit from this curriculum? Who the target population is has to be determined prior to setting curricular goals. I make this assertion because in my view the characteristics of the learners are limiting factors for what educational goals may be. By characteristics of the learner, I mean their physical growth and development. Physical growth patterns, the development of large and small muscle coordination, the onset of puberty, and the adolescent growth spurt are factors that should not be ignored in setting curriculum goals.

Cognitive growth and development of learners must be understood prior to determining curricular goals. The theory of intelligence of Binet and Terman have long dominated the study of education. I believe that the theory of intelligence as measured by the many "intelligence tests" are reported as I.Q. has been an inhibitor to educational improvement. I.Q. has come to be considered a fixed, largely inherited property of a person, as much a property as height or weight. We now have over fifty years of research conducted in a variety of disciplines that suggests that in normal individuals intelligence is learned. The interactions of organisms and environment produce intelligence. This field of study is usually referred to as cognitive development, with Vygotsky, Piaget, and Warner as its major theoreticians. However, several psychologists in personality theory, have findings consistent with cognitive psychology. I am referring here to the work of Kelly (1963), for example, which is not only concerned with cognitive development, but with emotional development as well.

The exciting aspects of these theories of cognitive and personal development are that they raise new questions about environments--about curricular environments. Inherited intelligence leaves us commiserating with children in their lack of prudence and foresight in picking their parents. Developmental theories open the door, they invite us to investigate details of curricular environments in terms of patterns of cognitive development found in the target population. Similarly Eric Erikson and more recently Jane Loevinger have provided dynamic theories of psycho-social and ego development.

The needs and concerns of learners at various periods or stages of development can now be specified with some confidence. They provide us, as educators with a dynamic view of children and youth developing. They offer us optimism and challenge. If we can utilize these theories as theories, as tentative and subject to testing, and avoid endowing each learner with new, fixed properties, our attention to them prior to goal setting in developing science curricula will serve us well.

Every time a new text book or a new curriculum is made available to schools, teachers hope it will solve their most serious problem--motivation. They keep hoping that every student in class will want to learn from these materials. Each time they are dismayed as they find groups of students who find the curriculum meaningless. By assiduous study of learners, in the literature and in science classrooms, we may be able to reduce such events to smaller and smaller numbers in fewer and fewer schools. Without such attention, we may continue to promise more than we can deliver, and continue to deliver much less than we could be capable of doing.

With the learner in mind, we can ask the question, "What can the sciences contribute to the development of this individual, this age group, this class?" Answering this question requires more than knowledge of the learner. It requires knowledge of what science is, and is not; and requires a capability to take from the sciences that which is appropriate in contributing to the development of well defined individuals. I do not mean to imply that we now know with full confidence what is

appropriate, but suggest we may be able to ask the question more precisely if we know both the target population of a curriculum and the nature of science.

A major problem for improved science curricula is the limited understanding of epistemology by both curriculum developers and curriculum users--science educators and science teachers. Science as the way of knowing rather than as one way of knowing is commonplace among the products of science and education departments. Not only is scientism prevalent, but a lack of understanding of the history and philosophy of science among those who choose and use science curricula is lamentable. The importance of such understanding has been emphasized in the literature for over a decade and a half, but little, if any, progress is being made in its implementation. The growth of scientific knowledge now makes it impossible for anyone to know a discipline. Chargaff (1975), a biochemist has said "I should have to read at least 10 papers a day to keep on top. This means that there are no authorities left, since only those who have no use for their knowledge can acquire it: doubtless a general predicament of all the natural sciences these days." This information overload leads to a scarcity of attention (Simon, 1971). A wealth of information creates a poverty of attention. We see this effect every day in classrooms, where there is a great deal of competition for a finite amount of available attention. In the battle for attention, one could speculate that the most meaningful information will be attended to by the organism. Meaningfulness must be defined

in terms of the learner for only the learner can provide the commodity. The task for developing useful curricula is a task of determining what aspects of science, in what curricula contexts, can be made meaningful to a particular target population. I am not suggesting that we stop where the learner's attentions are, but that we utilize these attentions in developing curricula that will contribute to development, in all the aspects previously described.

Science educators must keep in view the changing nature of scientific knowledge. Facts and constructs must be clearly separated. For example, is dominance in social groups a fact or a construct? In many curricula, dominance seems to be treated as a fact, but we know, or should know, that it is a construction, subject to change as new observations and different theoretical structures guide the observer.

Developing meaningful curricula may require going beyond the natural sciences into the social and behavior sciences, and into considerations of values. This may not be necessary for all children and youth in all curricula at all times. When we find problems in developing meaningful curricula, we should explore these and other alternatives.

This argument leads me to another critical issue for science education. The capability to experiment with different curricular structures is practically non-existent in the current context in which science education is conducted. New curriculum structures in the sciences are now funded almost solely by

the National Science Foundation. The private sector, to my knowledge, expends no funds on curriculum research. But programs qualifying for NSF support must be marketable by the public sector. They cannot be designed to learn how students interact with materials in classrooms. Current criticisms of efforts to produce more effective curricula may well reduce investment in even the rather conservative effort at curriculum innovation supported by the National Science Foundation. If science education loses this very limited means for curriculum development, I see little prospect in solving the very serious issues that I have presented.

The final issue that I will have time to mention is the issue of what it means to know. How do we know if individuals know enough when they leave formal schooling and, what is enough? Some individuals will leave before finishing twelve years of schooling. Others will have brief encounters with the sciences by the completion of the twelfth grade. A recent study (Boffey, 1976) indicates that three-fourths of the public remains confident in science and technology. Etzioni and Nunn (1974) found that "science has lost some support, many defectors are among the politically weaker, less informed, less educated groups." They asked, "To reach the most indifferent segments of the public, should the goals of science be modified so that they are more relevant socially and economically to 'forgotten Americans?'" I cannot answer for the scientific community, but I suggest that the goals of science education should definitely be modified for these Americans.

I do not believe that we will be able to achieve this change in goals without much better means for evaluating the effects of alternative curricula structures. Accountability will not go away by wishing it away, and we do not now have the means to measure even our currently espoused goals for science education. We can measure memory fairly well, but we have not moved far in measuring scientific thinking, processes of science, or even higher intellectual skills and abilities as defined by Bloom and his colleagues. Most of our instruments enable us to measure performance, but I know of none that enable us to measure competence. Here I use the distinction proposed by Doll (1975). Doll defines performance as "concerned with the doing of an act, while competence is essentially concerned with the basic, underlying, fundamental capabilities individuals draw upon when they perform." I cannot give further attention to this distinction here, except to say that I think of a performance as what individuals do on a final exam and competence as what they can do at some distance from the exam in applying understandings to a variety of new situations that logically and psychologically relate to the performance. Many teachers attest to the distinction when they assert that they didn't really understand a problem or an idea until they learned to teach it.

There are many other critical issues in science education such as the education of science teachers, the politics of science curriculum development and acceptance, the dissemination

and implementation of curriculum innovations, to name but a few. There is now a better knowledge base for the development of a science of science education than any group of science educators has ever had. Can we utilize this knowledge base to provide for a better education of all of the children of all of the people in the future? The opportunity is here, I hope we can.

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